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Exploiting Oceanic Residual Depth to Quantify Present-day Dynamic Topography at the Earth's Surface

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Convective circulation within the mantle causes vertical motions at the Earth's surface. This dynamic topography is time dependent and occurs on wavelengths of 1000s km with maximum amplitudes of ±2 km.

Convective simulation models have been used extensively to make predictions of dynamic topography and have thus far out-paced observational constraints. Here, the well-established relationship between seafloor subsidence and age is used to produce a global map of residual depth anomalies in the oceanic realm.

Care is taken to remove other causes of topography, including an isostatic correction for sedimentary loading that takes compaction into account, a correction for variable oceanic crustal thickness, and lithospheric thickening with age away from mid-ocean ridge spreading centres.

A dataset including over 1000 seismic reflection profiles and 300 modern wide-angle refraction experiments has been amassed, primarily on old ocean floor adjacent to the continents. Calculation of residual depth yields a map of present-day dynamic topography with amplitudes significantly larger than the errors associated with the corrections. One of the most interesting results occurs along the west coast of Africa, where two full 2000 km wavelengths of dynamic topography have been captured with amplitudes ±1 km that correlate well with the long-wavelength free air gravity anomaly.

Comparison with predictive models reveal poor to moderate correlations. This is a direct result of the limited resolution of the mantle tomography models used to set-up convection simulations and also the currently poor understanding of viscosity structure within the Earth. It is hoped that this residual depth dataset should provide an excellent surface boundary constraint for future convective simulation.